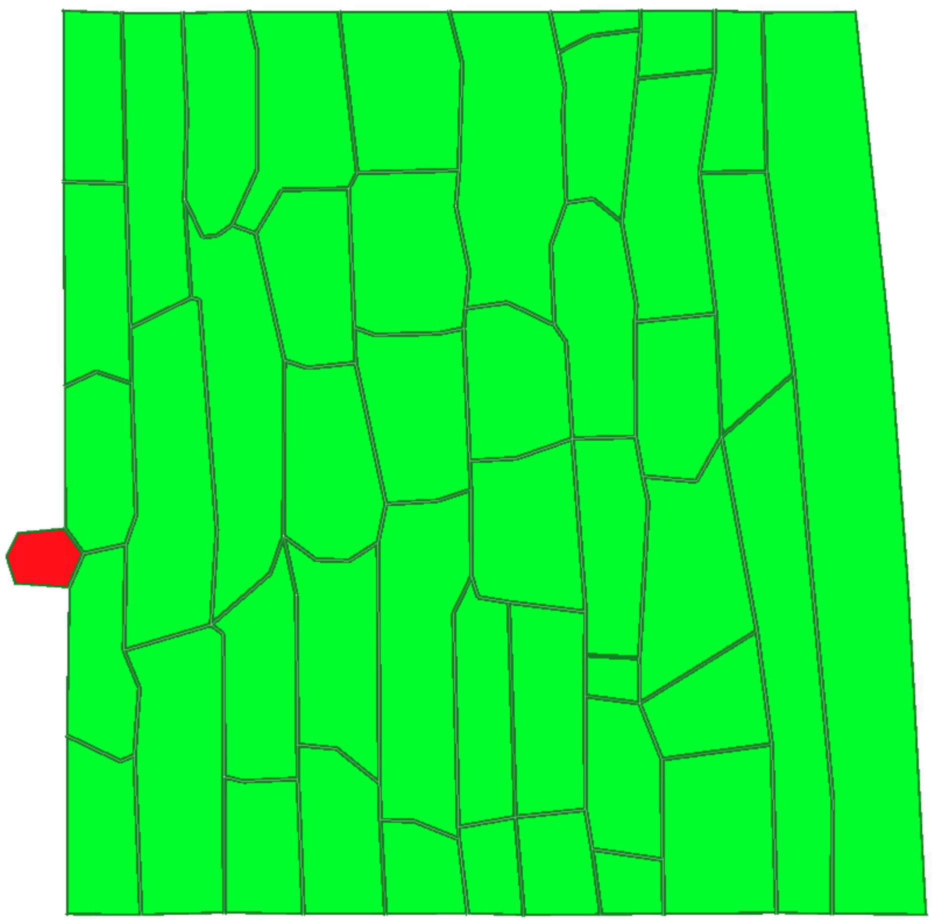
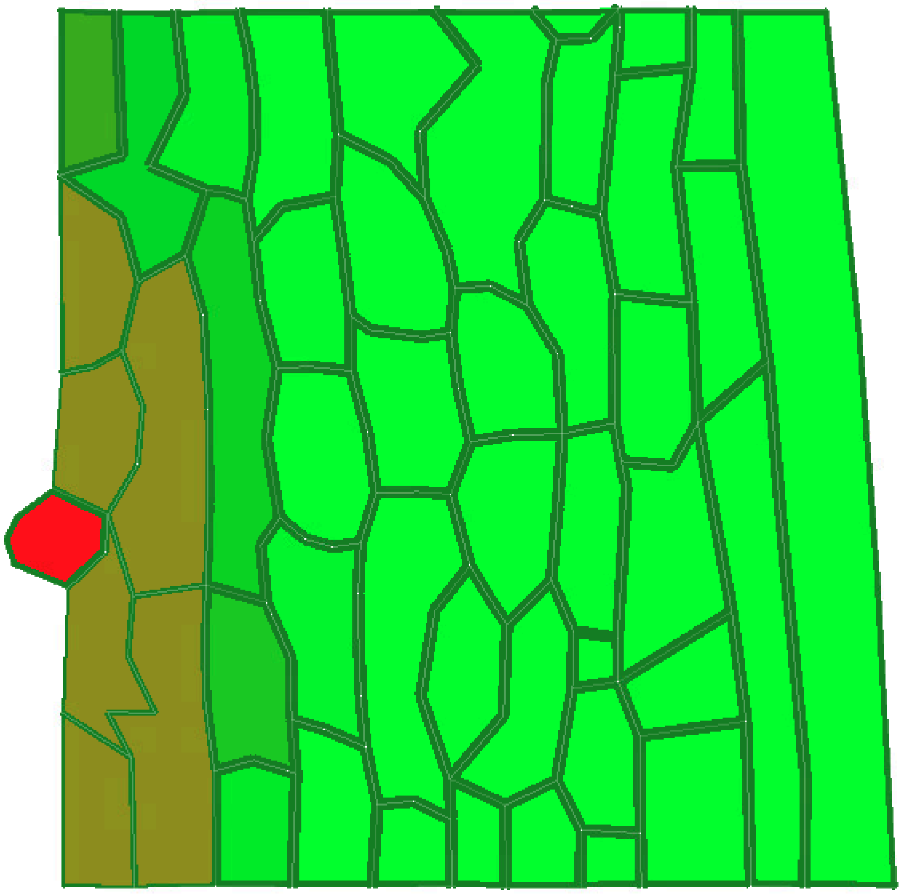
Assignment 4 - Plant systems biology

Exercise 1:
We start by running the model of pathogen infection, where one pathogen (red) infects a plant tissue (green). The pathogen is secreting a cell wall weakening chemical that reduces cell wall stability and helps the pathogen infect more cells.

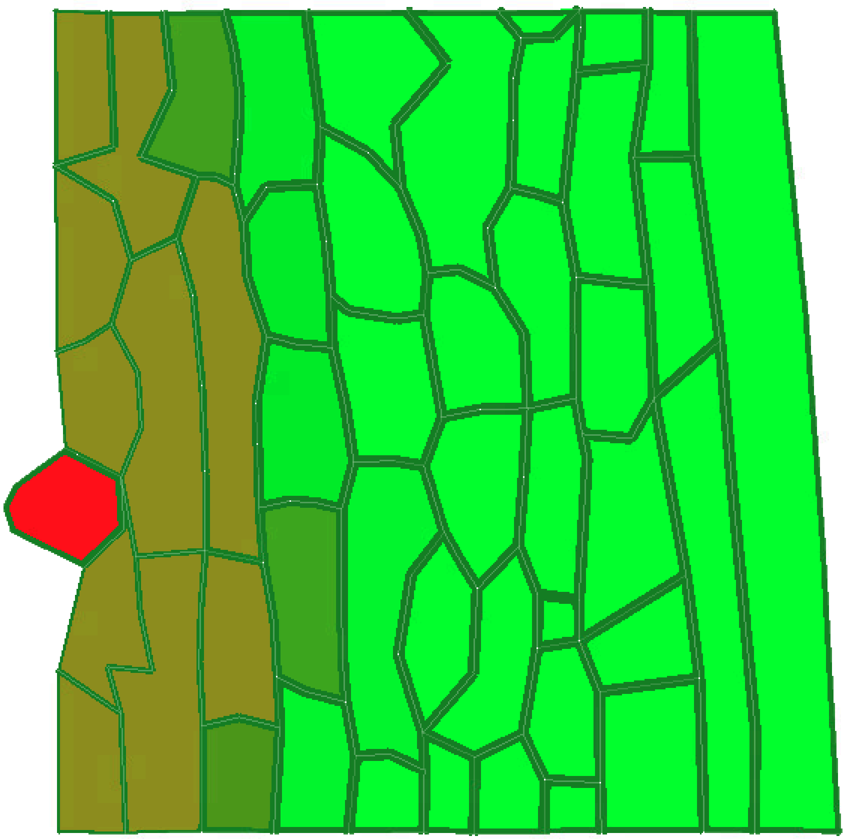
Hour 0: At hour 0 we notice that the pathogen is located outside of the plant tissue. The plant cells are healthy and intact and there are no signs of infection or cell wall weakening visible.



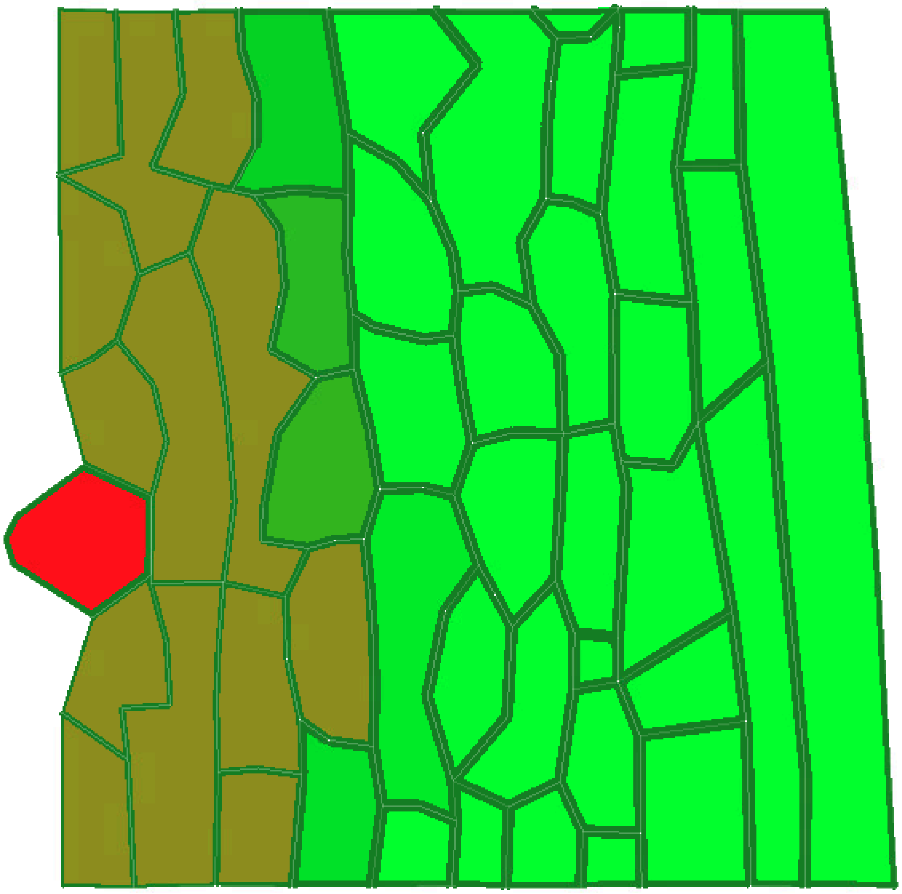
Hour 1: At hour 1 the pathogen starts affecting the closest neighboring cells. A brownish zone appears around the pathogen which indicates cell wall weakening.



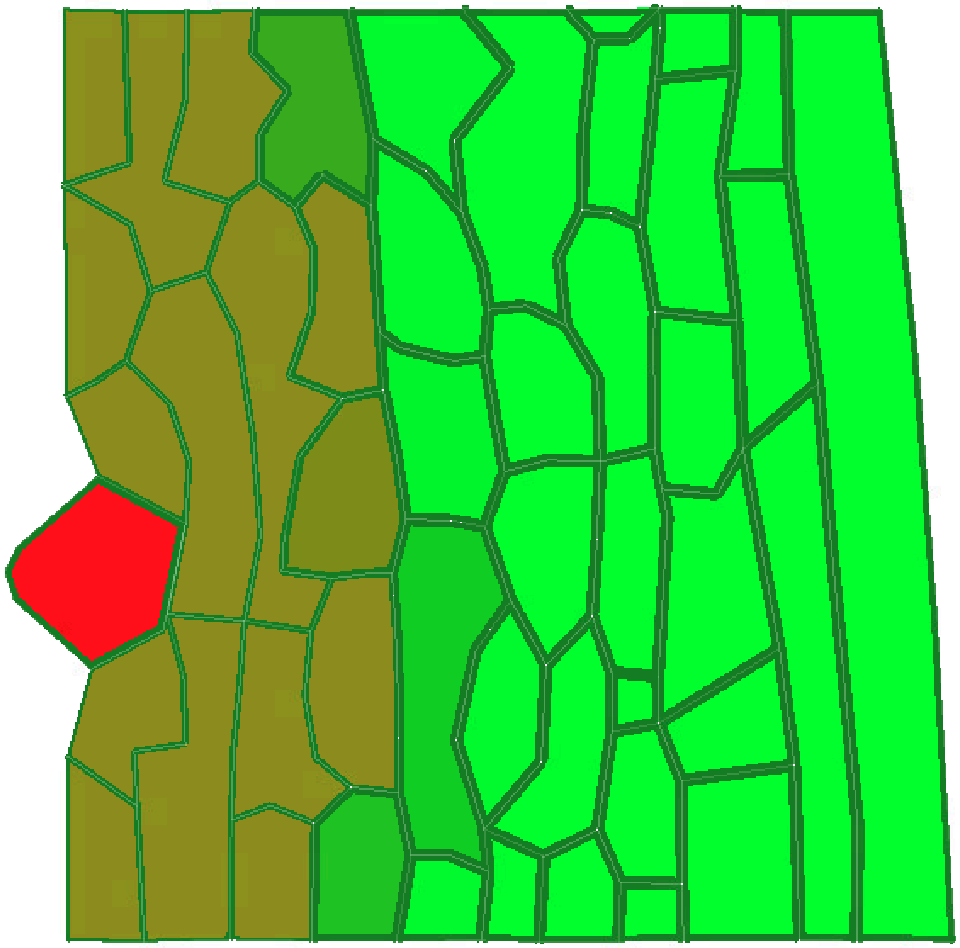
Hour 2: At hour 2 the infection spreads further inward causing more cells near the infection to get brownish meaning that their walls are compromised.



Hour 3: At hour 3 the pathogen continues to progress deeper in the tissue



Hour 4: At hour 4 the infected zone has expanded to nearly half of the tissue

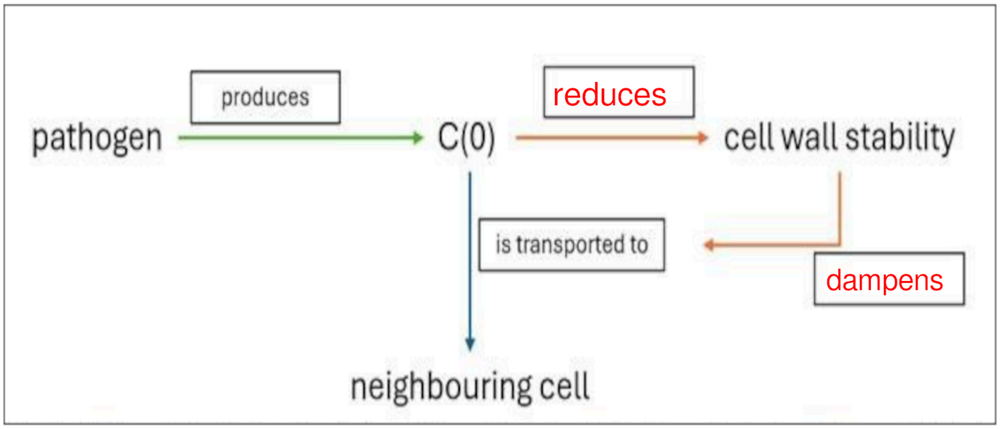


Conclusion: After 4 hours the pathogen weakens the plant cell walls and progressively invades the tissue. By the end of the simulation we can see a bigger portion of the tissue being compromised.

Exercise 2:
The section on CellHouseKeeping defines simple rules for each cell: if a cell is of type 2, its target growth area is enlarged, giving it faster or stronger growth potential. It also ensures that every wall element has an initial base length of 25, so the cell walls have a consistent starting structure

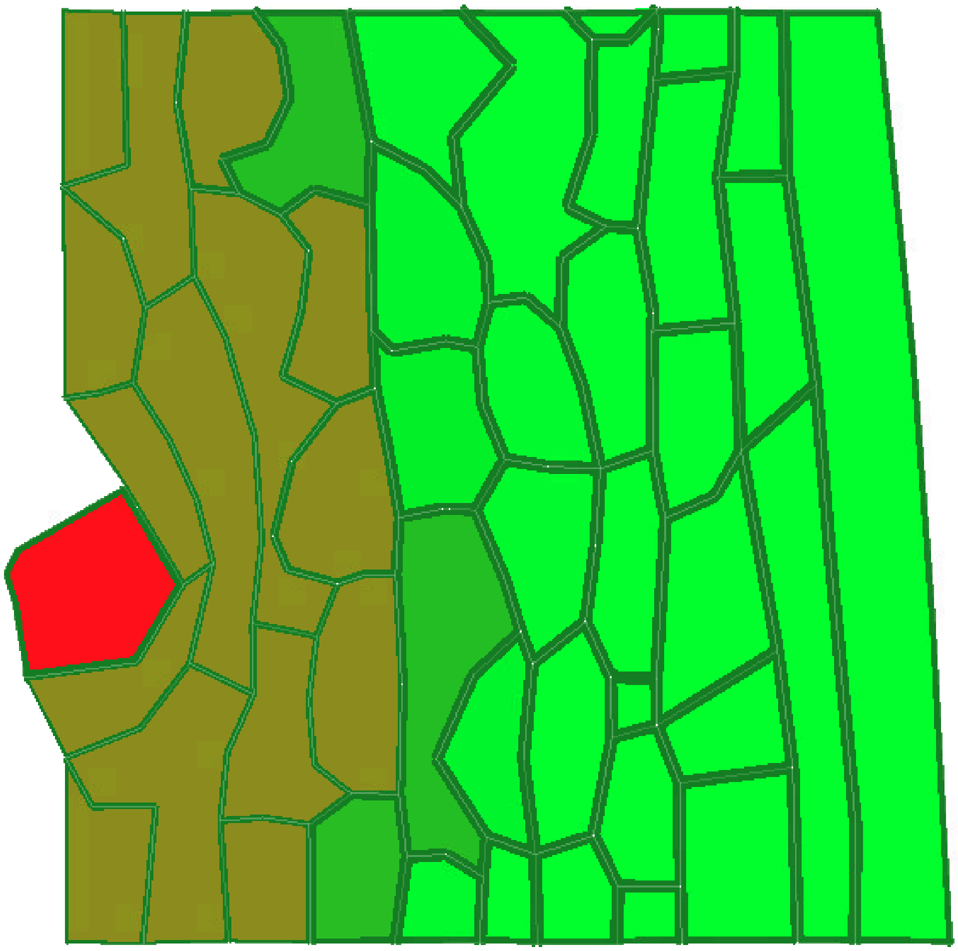
Exercise 3:

There is a feedback loop wherein the pathogen weakens the stability of the cell walls, which prevent it from reaching neighbouring cells. This causes it to spread progressively faster.

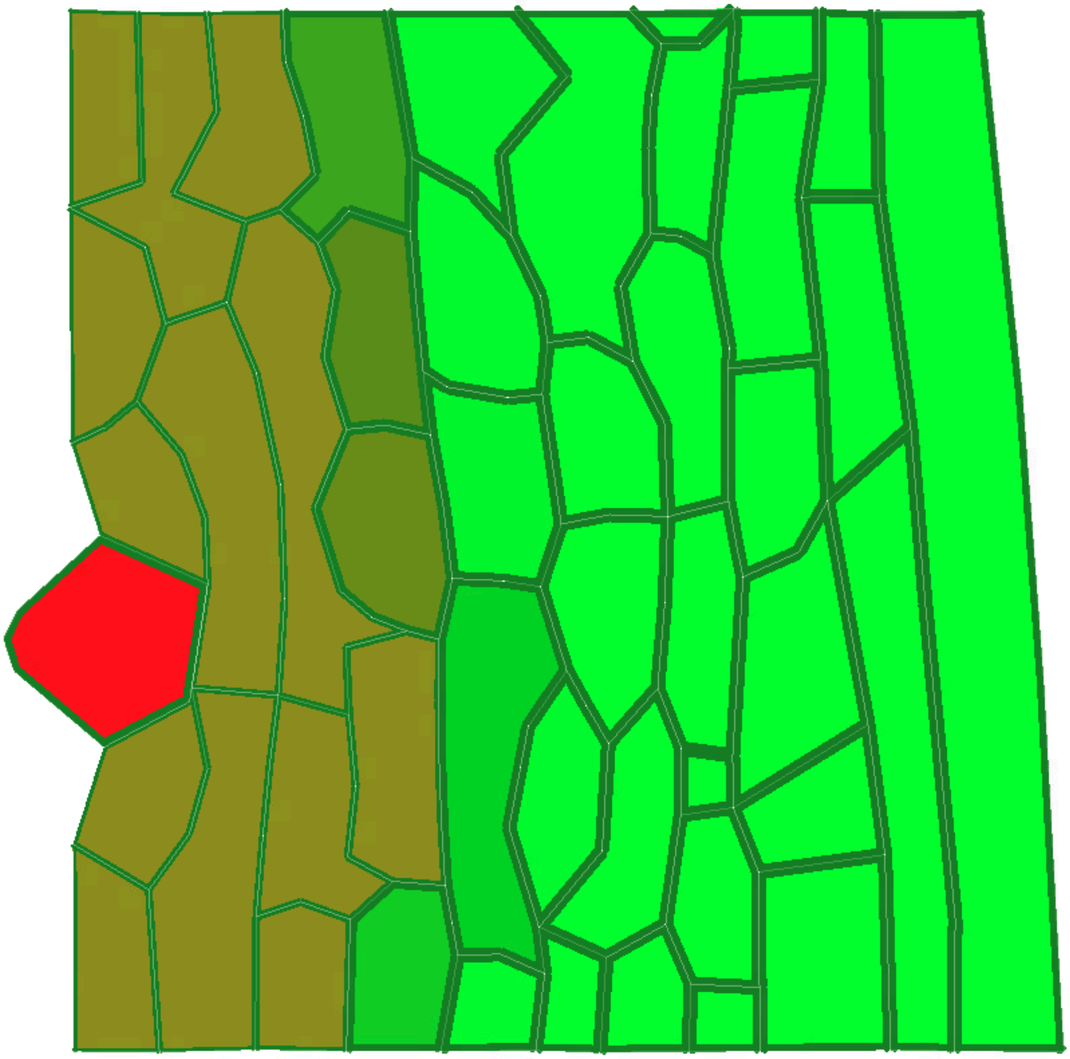


Exercise 4:

Decreased By 10:



Increased By 10:



When the diffusion coefficient is decreased, the pathogen's chemical remains tightly localized around the infection site, leading to a sharp, confined response. When it is increased, the chemical spreads broadly, producing a smoother gradient that reaches much farther into the tissue.

Exercise 5:
We could make it so that the uninfected cells produce another chemical when they sense a high amount of chemical 0, which would cause them to reinforce their cell walls, as well as signal the adjacent cells to do the same.

In CellDynamics:

```
If infected cell:
    dchem[0] = 0.1
    dchem[1] = 0.0
else:
    dchem = -0.001 * c->Chemical(0)

    If c->Chemical(0) > detectionThreshold:
        dchem[1] = 0.15
    else:
        Dchem[1] = -0.005 * c -> Chemical(1)
```

In CelltoCellTransport:
We do everything normally, but in the end we also do:

```
double signal_flux = length * par->D[1] * (w->C2()->Chemical(1) - w->C1()->Chemical(1))

dchem_c1[1] += corr1 * signal_flux
dchem_c2[1] -= corr2 * signal_flux
```

In CellHouseKeeping:

We simply add in the else statement:

```
If c->Chemical(1) > 0.1:
    Stiffness = 2.5 + (2.0 * c->Chemical(1))
```